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EXPLOSIBILITY TESTS ON ALUMINUM CHIPS/DUST

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EXPLOSIBILITY TESTS ON ALUMINUM CHIPS/DUST

by

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ABSTRACT

Samples of aluminum chips/dust from the Ideal Metals plant failed to explode in the 20 L vessel even with a high energy ignitor. The minimum ignition temperature of the dust cloud formed from this material was 700°C. The minimum ignition temperature of a dust layer was >720°C. The absence of fine dust and the use of a sticky, less flammable coolant are the factors causing the low hazard of this material.

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KEYWORDS: dust, explosibility, aluminum

ESSAIS PORTANT SUR L'EXPLOSIVITÉ DE FRAGMENTS ET DE POUSSIÈRES D'ALUMINIUM

par

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RÉSUMÉ

Des échantillons de fragments et de poussières d'aluminium provenant de l'installation Ideal Metals n'ont pas explosé dans le contenant d'une capacité de 20 L servant aux essais, même si un dispositif d'allumage à niveau énergétique élevé à été utilisé. La température minimale d'inflammation du nuage de poussière produit par ces matériaux était de 700°C. La température minimale d'inflammation de la couche de poussière était de <720°C. L'absence de poussière fine et l'utilisation d'un fluide de refroidissement plus collant et moins inflammable sont les éléments qui contribuent à minimiser les risques que comporte l'utilisation de ces matériaux.

Mots-clé : Poussière, explosivité, aluminium

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CONTENTS

	Page
ABSTRACT	i
RESUME	ii
INTRODUCTION	1
SIEVE ANALYSIS	1
MINIMUM IGNITION TEMPERATURE TESTS - DUST CLOUDS	2
MINIMUM IGNITION TEMPERATURE - DUST LAYERS	3
EXPLOSION TESTS	4
DISCUSSION	5
CONCLUSIONS	6
REFERENCES	7

INTRODUCTION

Ideal Metals is in the process of designing a dust collection/ventilation system for their plant in Brampton, Ontario. Their purpose is to improve the atmosphere existing in the plant by removing particulates, mostly aluminum. They are concerned, however, that improvement on the health side may lead to a safety hazard, namely, the potential explosion of aluminum particles in the dust collector. The explosibility of aluminum dust is well known (1). Therefore, the explosibility characteristics of typical material that will be collected in the cyclone/hopper were examined.

According to Ideal Metals, virtually all the material would be aluminum alloys containing up to 2.9% magnesium. Electrasol MS901XX, a semi-synthetic coolant, is used in machining and therefore would also be present.

SIEVE ANALYSIS

The sample received consisted mainly of aluminum alloy turnings with a small amount of dust. The sample appeared somewhat damp and sticky.

A portion of the sample was dried in an oven at 110°C. It achieved constant weight after 3 hours, with a total weight loss of 0.39%.

A dry sieve analysis was carried out on both the as received material and the dried material, with the following

results:

sieve	opening (mm)	% by weight as received	% by weight dried
+20	0.85	90.0	88.7
-20/+30	0.60	4.9	5.6
-30/+40	0.425	2.1	3.5
-40/+50	0.30	1.1	1.4
-50/+60	0.25	0.2	0.3
-60/+80	0.18	0.3	0.4
-80		0.5	0.1

The coarsest three fractions consisted solely of turnings, the next two fractions were a mixture of turnings and dust, and the finest two fractions were mainly dust. The sieves separated the turnings on the basis of thickness, rather than diameter as in the case of rounder particles. The difference between the as received and dried is probably not significant because of the natural variability in the material.

MINIMUM IGNITION TEMPERATURE TESTS - DUST CLOUDS

The minimum ignition temperature (m.i.t.) test was carried out using the Godbert-Greenwald apparatus developed by the U.S. Bureau of Mines (2). In brief, a pulse of air from a reservoir is released quickly through a solenoid valve into a sample chamber in which the dust has been placed. The air/dust mixture then travels downwards into a vertical tubular furnace which had been heated to the test temperature. Observation of

flames or sparks emitted from the bottom of the furnace indicates that the m.i.t. is at or below the test temperature. The test temperature is varied in 10°C increments until the lowest temperature is reached at which sparks or flames can be observed. The sample size and air pulse are varied starting 10°C below that temperature to determine whether that is indeed the m.i.t.

For the "as received" material, the m.i.t. was determined to be 700°C. Field (3) quotes values of 420°C for 6μ aluminum particles, 610°C for 29μ particles, and 610°C for flakes (unspecified size).

MINIMUM IGNITION TEMPERATURE - DUST LAYERS

The Setchkin apparatus is an ASTM Standard Test (4) used for determining the minimum ignition temperature of plastics. It consists of a tubular vertical furnace with closed bottom, with air pumped downwards through the heating coils and then upwards inside the cavity. A sample holder is placed halfway down the cavity with a thermocouple placed below the sample for measuring the air temperature and another thermocouple immersed in or just above the sample to detect any exothermic events in the sample. A datalogger is used to record the temperatures as a function of time.

The Setchkin apparatus can also be used to measure the m.i.t. of dust layers in the same way. A 0.5 g sample of the aluminum was placed in a crucible, and the temperature of the furnace increased at the standard rate. No evidence of any change in the aluminum could be observed up to the maximum

temperature of 720°C.

EXPLOSION TESTS

The 20 L vessel originally designed by the U.S. Bureau of Mines (5) and modified by us (6) was used for these tests. Briefly, air at a high pressure is released through a solenoid valve and disperses dust from a small chamber into the previously evacuated 20 L vessel through a nozzle . After the dust has been dispersed, an ignition source ignites the dust cloud. A digital oscilloscope records the signal from a strain-gauge pressure transducer mounted on the vessel. Following the test, the combustion gases are pumped through a paramagnetic oxygen analyzer to measure the residual oxygen.

Because of the nature of the particles being tested in this study, they would not go through the openings of the nozzle. Therefore, the weighed sample was placed inside the 20 L vessel over the nozzle so that the air leaving the nozzle would disperse the sample. The dispersion and ignition can be observed through an observation window in the vessel. Qualitatively, it appeared that the dispersion was adequate.

The first two tests were carried out using the standard ignition source, a continuous arc discharge, the standard dispersion pressure of 1100 kPa, and a concentration of 250 g/m^3. There was no evidence of any explosion or, indeed, any reaction. In order to ensure that the nonexplosibility was not due to inadequate dispersion of the aluminum, the test was repeated using the highest dispersion pressure possible in our

system (1300 kPa). Again, there was no evidence of any reaction.

Tests were also carried out using a powerful chemical ignitor (5 kJ Sobbe) at concentrations of 250 and 1040 g/m^3. These higher energy ignitors are used for dusts that have a high minimum ignition energy. Neither test produced any reaction, thereby indicating that insufficient ignition energy and high minimum explosible concentration were not the cause of the nonexplosibility.

Finally, tests were carried out on a dried portion of the sample at a concentration of 800 g/m^3 using the chemical ignitor. Again, there was no evidence of reaction.

After each test, the gases remaining in the vessel were pumped out through an oxygen analyzer. If any combustion had occurred, the oxygen concentration would have decreased. This was not the case; therefore, no combustion had occurred. Visually, the aluminum particles appeared to be unchanged.

DISCUSSION

The material as received was rather coarse. Usually one is concerned about the explosibility of the -200 mesh fraction, which, in this case, did not exist. The relatively large particle size means that the surface area (i.e. potential reaction zone) for a given mass is quite small, as well as providing a large heat sink.

The Electrasol MS901XX used in the machining operations appears to be useful in reducing the explosibility hazards. Being a rather sticky substance, it would tend to eliminate small

particles (which are the most hazardous) by attaching them to other surfaces. It may also, to some extent, decrease the reactivity of the surface of the aluminum by coating it with the material which is less reactive than aluminum.

CONCLUSIONS

The results of both the m.i.t. and explosibility tests indicate that this material does not present any significant fire or explosion hazard. This conclusion is based on the sample tested being truly representative of the plant material in terms of particle size/thickness, elemental composition and quantity and type of coolant used.

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